MLPC Inc.
Mound Laser & Photonics Center

MDA Phase I SBIR

Title: "Development of a Laser Micromachining Process to Fabricate SiC Mirrors"

MDA Phase I STTR

Title: "Incorporation of Advanced Sensor Technology to Enable Complex Laser Micromachining of Silicon Carbide and Silicon Nitride Devices"

Dr. Larry R. Dosser

Mirror Technology Days

August 16-17, 2005

MLPC Inc.
Mound Laser & Photonics Center

Presentation Outline

Who is MLPC?

Phase I SBIR & STTR Objectives and Results

Proposed Phase II SBIR & STTR programs

Backside Substrate Laser Machining

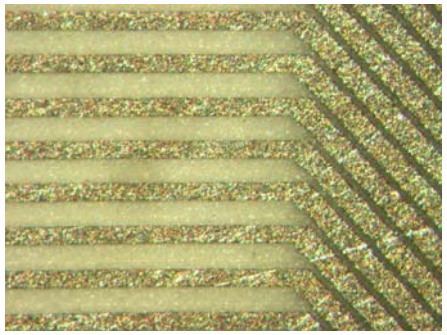
Who is MLPC?

- Located at Mound Laboratory, Miamisburg, Ohio
- Former DOE Nuclear Weapons Production Facility (1945-1991)
- MLPC starts in October 1995 as part of defense conversion
- Business Model dynamically connects DoD & Commercial sectors

- 50% Commercial job shop
- 50% Government funded R&D
- Area universities → personnel, diagnostics
- On-the-job training (skilled workforce)
- Student job → permanent position

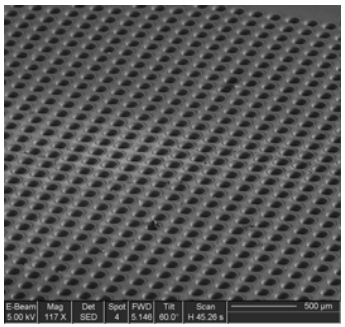
Laser Micro-Fabricated Devices

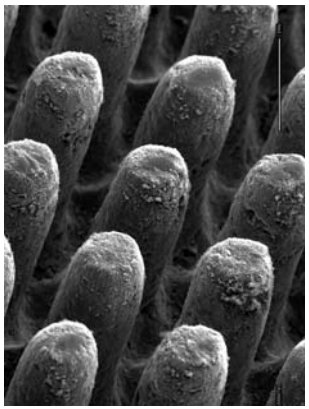
Direct Write Circuitry

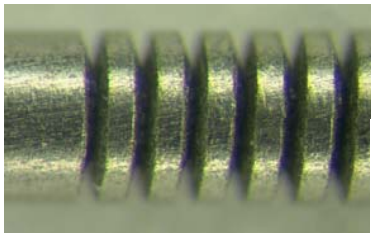


- Metals
- Ceramics
- Polymers
- (WBG) Semiconductors
- Superconductors
- Shape memory polymers

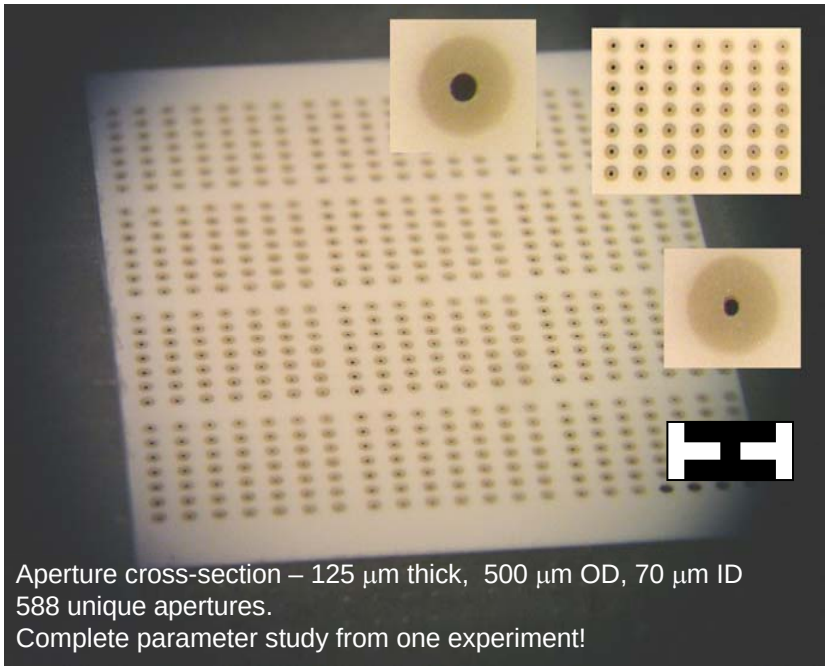
Surface Texturing / Micro- structuring







Complex 3-D devices



Aperture cross-section – 125 μm thick, 500 μm OD, 70 μm ID
588 unique apertures.
Complete parameter study from one experiment!

MLPC Inc.
Mound Laser & Photonics Center

MDA SBIR Phase I Objectives

- Evaluate the feasibility of laser micromachining of SiC for mirror substrate applications.
- Determine the best laser for producing the optimal surface finish and material removal rates.
- Develop the prototype concept for an automated laser micromachining workstation.
- Evaluate the business case for laser micromachining of SiC mirrors.

Phase I SBIR Results
Demonstrate the Potential of Laser SiC Machining

1. Improved Surface Roughness
   - SiC CVD : R_a ~ 1480 nm, PTV ~ 50 μm
   - Laser machined : R_a ~ 750 nm, PTV ~ 13 μm

2. Competitive Processing Rates
   - Laser technology is currently showing rapid advances and is scalable

3. Precision Material Removal
   - 2 μm material removed per laser beam pass
   - Surface finish improves as material is removed

MLPC Inc.
Mound Laser & Photonics Center

MDA STTR Phase I Objectives

- Evaluate NDE techniques for laser machined SiC.
- Define the optimal laser processing window.
- Evaluate *In-situ* laser ultrasonics for process monitoring and defect detection.

Phase I STTR Results

Investigate the effects of laser micromachining SiC substrates

1. No micro-cracks are observed
   - Wide range of laser processing parameters (multiple lasers)
   - Diagnostics performed included AFM, SEM, NSOM, EDAX, WLIM

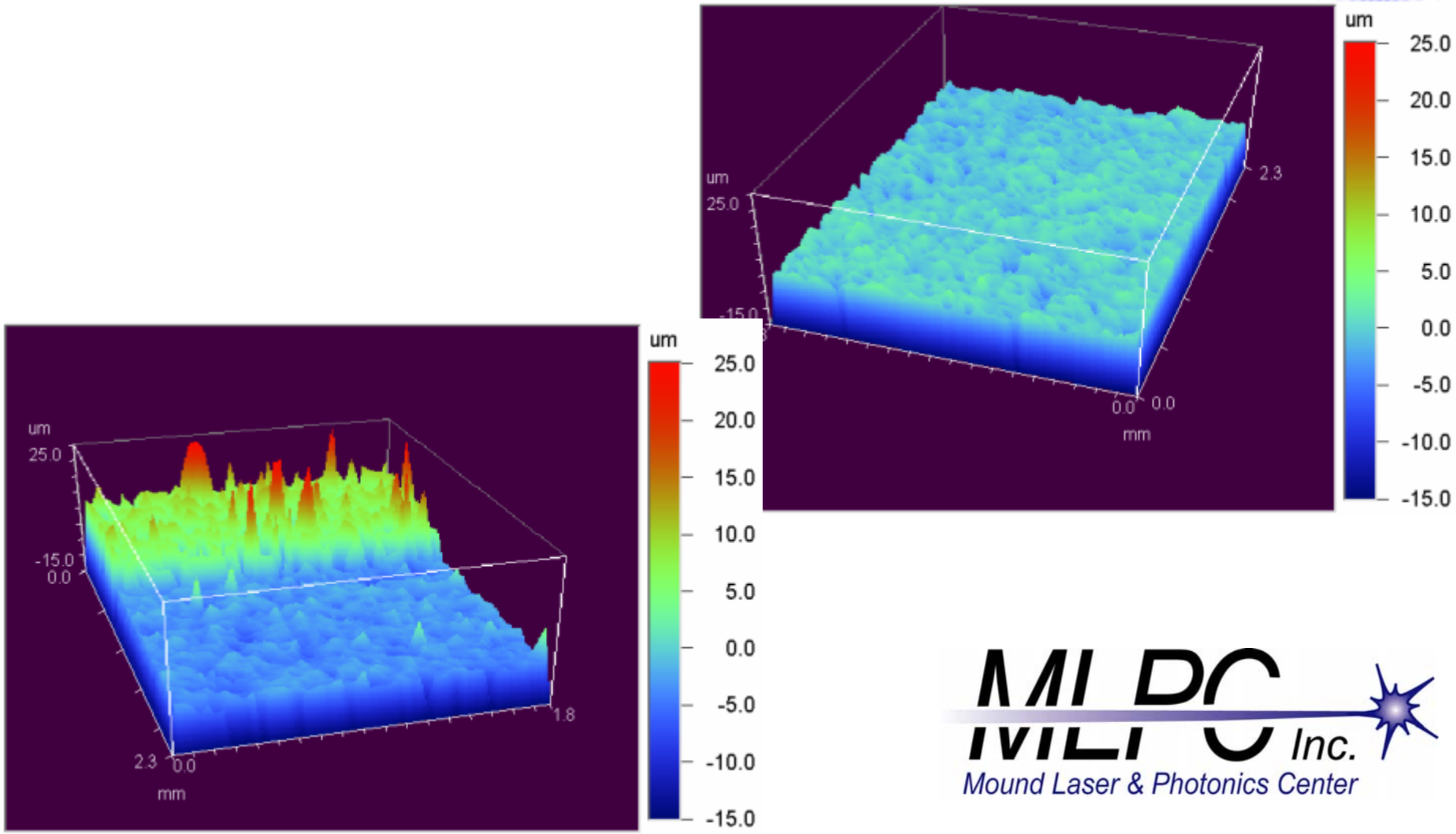
2. Broad range of tunabilty
   - Optimize wrt material removal rate or surface finish

3. Laser ultrasonics for defect detection in SiC was demonstrated
   - Potential *in-situ* process monitoring
   - Not necessary

4. White Light Interferometry is most useful characterization technique
   - Proposed in Phase II as an online contour mapping technique

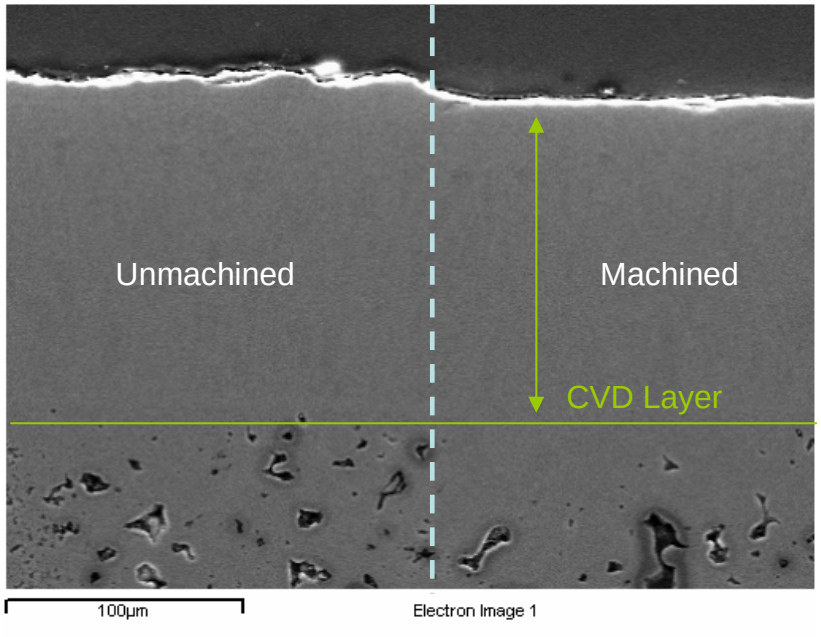
MLPC Inc.
Mound Laser & Photonics Center

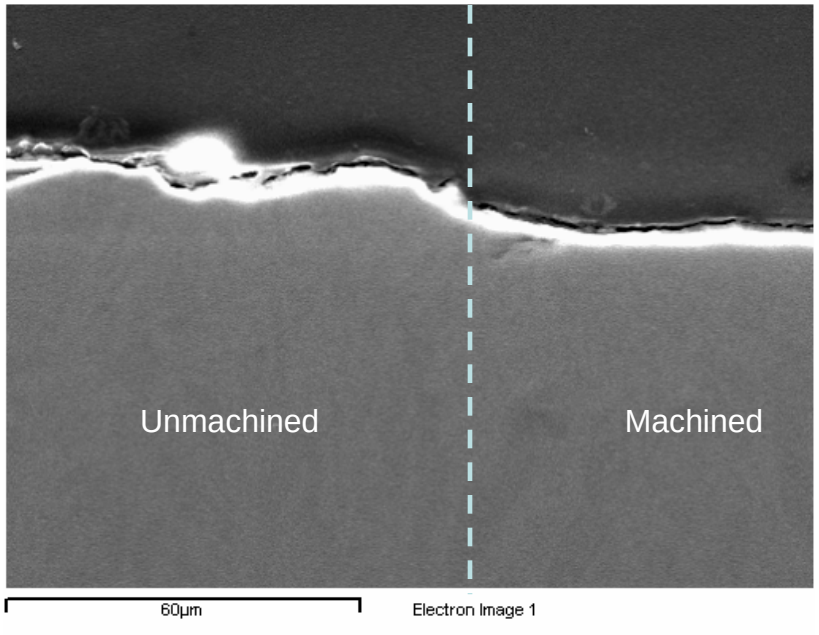
Optical Metrology
White Light Interferometry



MLPC Inc.
Mound Laser & Photonics Center

SEM Cross Section





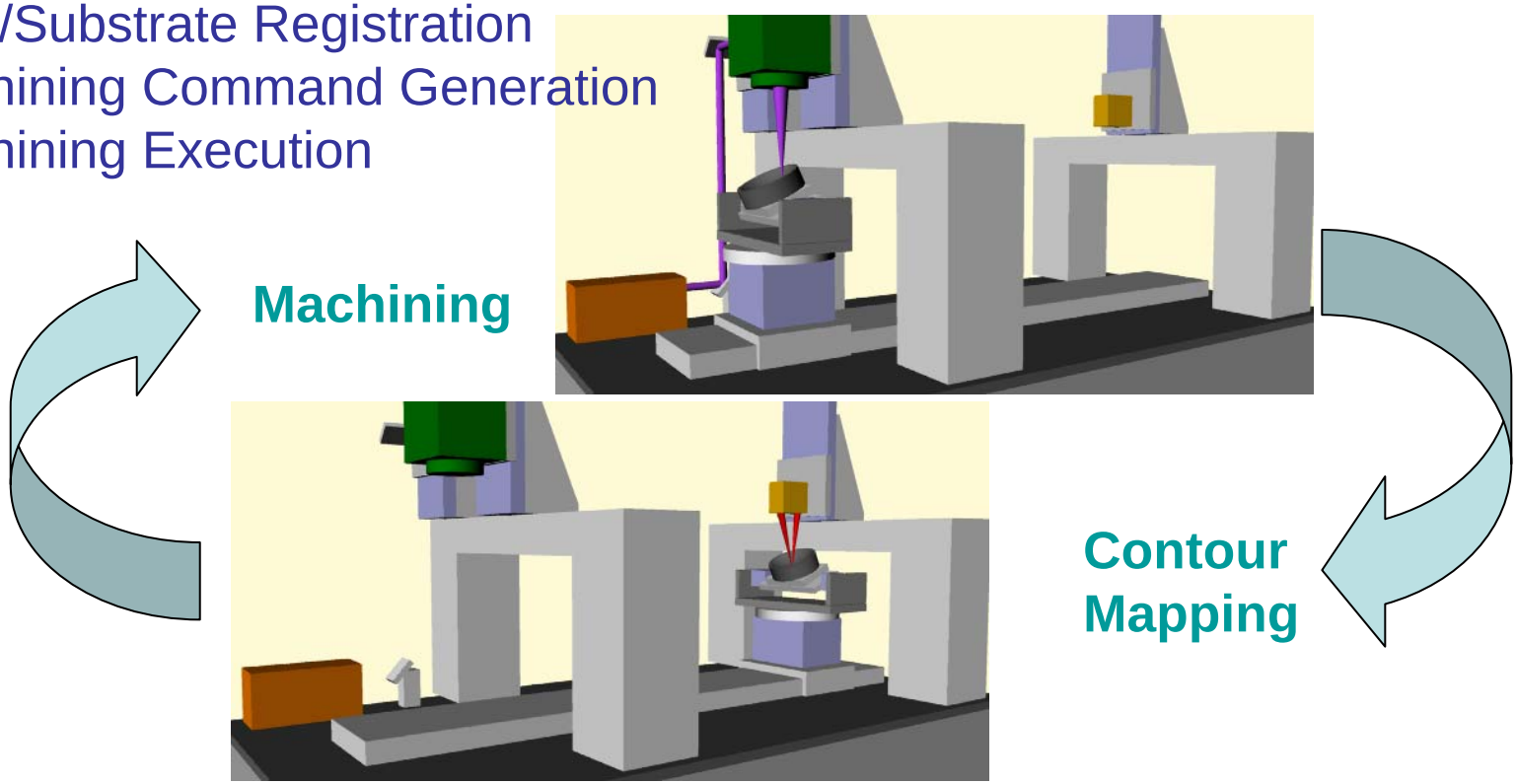
MLPC Inc.
Mound Laser & Photonics Center

Phase II SBIR / STTR Proposal

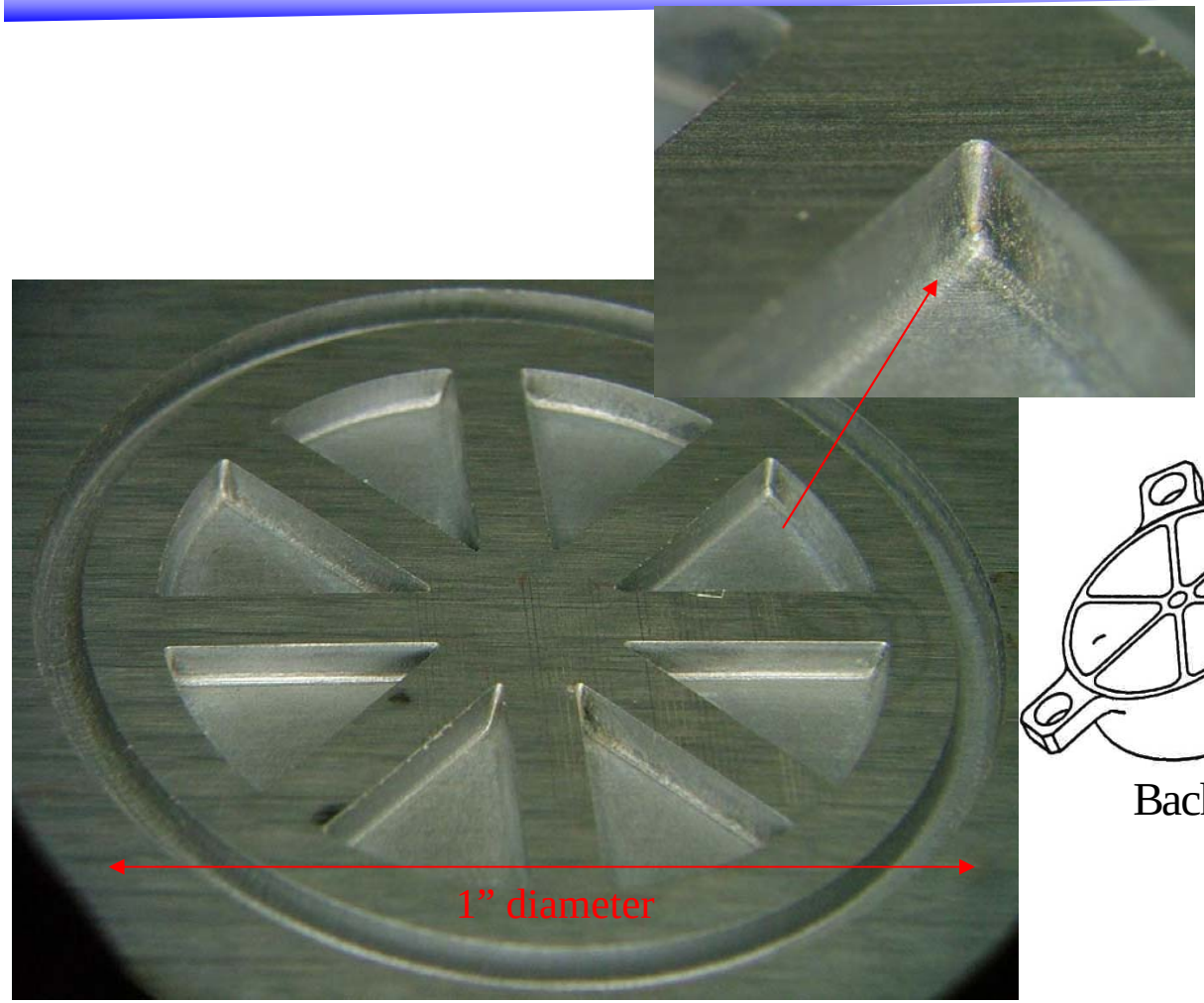
Development of Prototype Closed-Loop Machining Capability

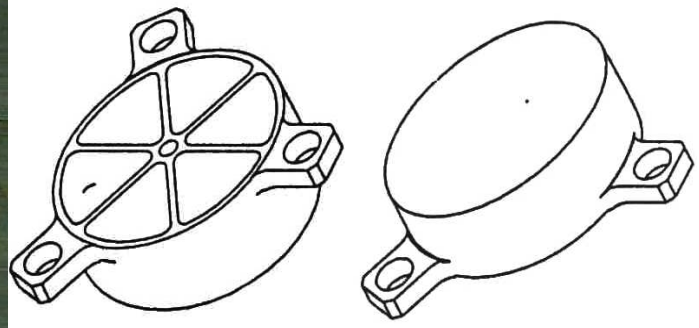
- Fully automated laser machining workstation incorporating high resolution metrology

- Application Specific Software Development
  - CAD/Substrate Registration
  - Machining Command Generation
  - Machining Execution



Mirror Substrate Backside Machining

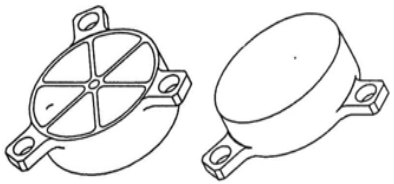


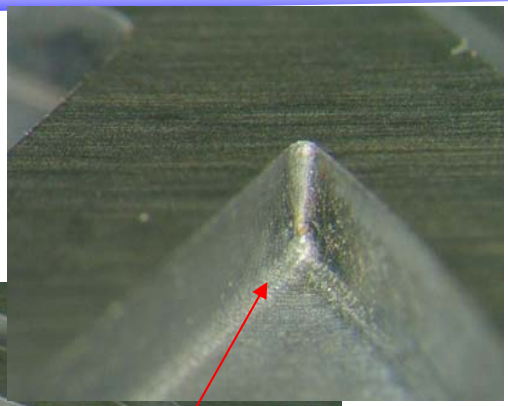


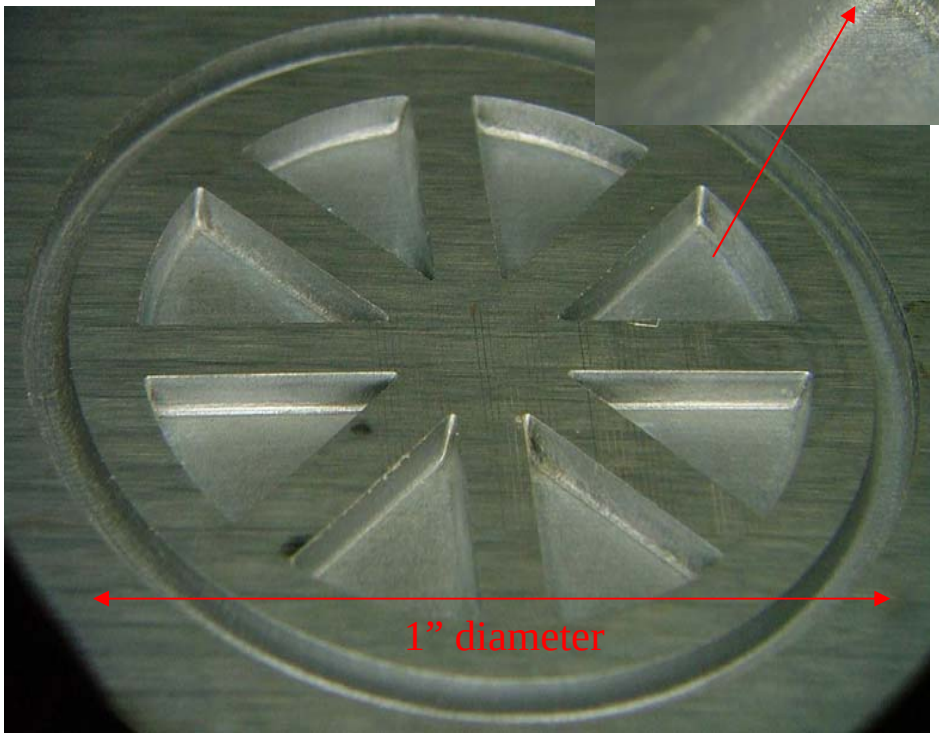
Back Front

MLPC Inc.
Mound Laser & Photonics Center

Mirror Substrate Backside Machining







Silicon Carbide (SiC)

Boron Carbide (B_4C)

MLPC Inc.
Mound Laser & Photonics Center

MLPC Inc.
Mound Laser & Photonics Center

MDA Phase I SBIR

Title: "Development of a Laser Micromachining Process to Fabricate SiC Mirrors"

MDA Phase I STTR

Title: "Incorporation of Advanced Sensor Technology to Enable Complex Laser Micromachining of Silicon Carbide and Silicon Nitride Devices"

Mirror Technology Days

August 16-17, 2005